USGS

Sound Waves

Coastal Science and Research News from Across the USGS

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Fieldwork

Submarine Groundwater Discharge Along the West Florida Shelf: Is Groundwater an Important Nutrient Source for Florida's Red Tides?

By Christopher Gerald Smith

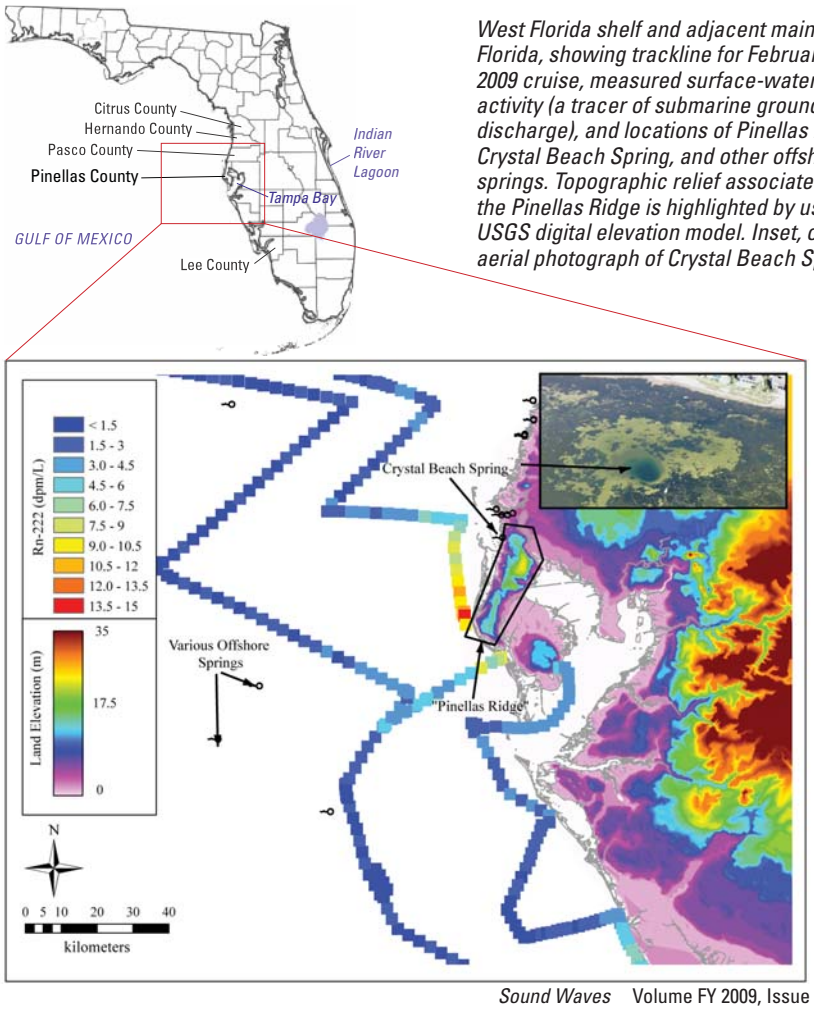
Harmful algal blooms have been observed along the west Florida shelf and adjacent water bodies for more than 150 years (some suggest as long ago as 1570), with the first historically documented bloom dating back to 1854. Modern harmful algal blooms, commonly referred to as "red tides," are dominated by the brevetoxin-producing dinoflagellate *Karenia brevis*. Brevetoxins are neurotoxins that pose a threat to marine and human health. The greatest densities of *K. brevis* blooms generally occur along the west Florida shelf between Pinellas and Lee Counties, Florida.

One of the main questions about harmful algal blooms on the west Florida shelf is, how do these blooms initiate and maintain themselves in an area that appears to have limited available nitrogen, one of the nutrients that algae require? Several hypotheses have been proposed to explain the sustained and increased growth of large *K. brevis* blooms on the nitrogen-limited west Florida shelf, including transport of nitrogen-enriched Mississippi River water to the area during summer months, utilization of nitrogen fixed by *Trichodesmium* spp. (a blue-green alga that fixes atmospheric nitrogen into ammonia, which can be used by other organisms as well as by *Trichodesmium*), and a supply of nitrogen internal to the bloom (excreted by zooplankton, for example, or generated by the decay of fish killed by the bloom).

Another possible source of nitrogen for fueling *K. brevis* blooms is the movement of nitrogen from the land to the ocean through submarine groundwater discharge—the flow of water from underground aquifers into the ocean, either through discrete submarine springs or by more diffuse flow from sediment into overlying seawater. To date, very few studies of benthic flux—the exchange of water between aquifers and the ocean—have been conducted along the west Florida shelf, leaving a great deal of uncertainty as to the role of submarine groundwater discharge in delivering nutrients to the coastal ocean.

Currently, U.S. Geological Survey (USGS) scientist **Christopher Smith** is addressing this uncertainty by measuring nutrient fluxes related to submarine groundwater discharge along the west Florida shelf and evaluating whether this source is significant relative to the nutrient demands of recurrent harmful algal blooms. **Smith** is a Mendenhall Postdoctoral Research Fellow at the USGS Florida Integrated Science Center office in St. Petersburg. His current

(Submarine Groundwater continued on page 2)



West Florida shelf and adjacent mainland Florida, showing trackline for February 2009 cruise, measured surface-water ^{222}Rn activity (a tracer of submarine groundwater discharge), and locations of Pinellas Ridge, Crystal Beach Spring, and other offshore springs. Topographic relief associated with the Pinellas Ridge is highlighted by using a USGS digital elevation model. Inset, oblique aerial photograph of Crystal Beach Spring.

Sound Waves

Editor
Helen Gibbons
Menlo Park, California
Telephone: (650) 329-5042
E-mail: hgibbons@usgs.gov
Fax: (650) 329-5190

Print Layout Editors
Susan Mayfield, Sara Boore
Menlo Park, California
Telephone: (650) 329-5066
E-mail: smayfiel@usgs.gov; sboore@yahoo.com
Fax: (650) 329-5051

Web Layout Editor
Jolene Shirley
St. Petersburg, Florida
Telephone: (727) 803-8747 Ext. 3038
E-mail: jshirley@usgs.gov
Fax: (727) 803-2032

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Contents

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Deadline: The deadline for news items and publication lists for the September issue of *Sound Waves* is Friday, July 10.
Publications: When new publications or products are released, please notify the editor with a full reference and a bulleted summary or description.
Images: Please submit all images at publication size (column, 2-column, or page width). Resolution of 200 to 300 dpi (dots per inch) is best. Adobe Illustrator© files or EPS files work well with vector files (such as graphs or diagrams). TIFF and JPEG files work well with raster files (photographs or rasterized vector files).

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Fieldwork, continued

(Submarine Groundwater continued from page 1)

research builds on his earlier Ph.D. work (Louisiana State University), which focused on using uranium-series radionuclides to quantify submarine groundwater discharge to Indian River Lagoon, Florida, and to understand how mixing between fresh and saline groundwater within the "subterranean estuary" affects the use of these radionuclides as groundwater tracers.

Chris Smith *collects water samples at Indian River Lagoon, Florida, as part of his Ph.D. research at Louisiana State University. Photograph courtesy of* ***Jaye E. Cable****.*

To explain the extensive harmful algal blooms observed throughout the year 2005, **Peter Swarzenski** of the USGS and **Chuanmin Hu** and **Frank Muller-Karger** of the University of South Florida (USF) have hypothesized that the precipitation associated with Hurricanes Charley, Frances, Ivan, and Jeanne had a twofold effect on the movement of nutrients from the land to the west Florida shelf: (1) an immediate effect by enhancing surface runoff and (2) a delayed effect by recharging the coastal aquifer and increasing submarine groundwater discharge along the coast. Most of their coastal-groundwater data linking submarine groundwater discharge to nutrients were derived from studies conducted in Tampa Bay. To test for a link between submarine groundwater discharge and nutrients on the west Florida shelf, **Smith** is measuring radon (^{222}Rn) and radium (^{223,224,226,228}Ra) isotopes (common submarine-groundwater-discharge tracers), as well as dissolved-inorganic-nutrient and metallic-ion concentrations in surface, ground, and pore waters. One area that he is investigating is the coastal water off the densely populated Pinellas County peninsula, which lies between Tampa Bay and the west Florida shelf.

In descriptions of Florida's groundwater system, the most commonly discussed features are freshwater springs, sinkholes, and the highly transmissive Floridan aquifer. Not much attention is paid to the shallow deposits that overlie the Floridan aquifer, especially in coastal areas; with respect to human demands, many of these deposits simply do not produce enough water to be viable primary water sources. In coastal areas, however, it is these shallow aquifers that are directly recharged by precipitation and are the most sensitive to human activity—such as application of pesticides, herbicides, and fertilizers and installation of underground storage tanks. One such aquifer in northwestern Pinellas County consists of a relatively thick (20 to 30 m) section of mixed siliciclastic and carbonate sedimentary deposits that form a prominent ridge near the coast (hereinafter referred to as the "Pinellas Ridge"). This local high is a recharge zone for the surficial aquifer and, in this area, the underlying Floridan aquifer. The elevation of water within the aquifers in this ridge causes groundwater to flow down toward Tampa Bay and the Gulf of Mexico.

Smith has been collecting data near the north end of the Pinellas Ridge at an offshore freshwater spring known locally as Crystal Beach Spring (near Crystal Beach, Florida) on the Gulf of Mexico side of the ridge. The spring is approximately 150 m offshore in St. Joseph Sound and approximately 4 km from the ridgetop. Spring-discharge estimates made by the Southwest Florida Water Management District in 2002 range from 0.15 to 0.63 m^3/s. Using a surface-water mass balance of ^{222}Rn, **Smith** estimated the discharge in January 2009 at 0.22 to 0.81 m^3/s. The discharge from the spring and the dissipation of the freshwater plume throughout St. Joseph Sound are moderated by tides and by wind-driven vari-

(Submarine Groundwater continued on page 3)

(Submarine Groundwater continued from page 2)

ations in water level. During the Southwest Florida Water Management District study, surface water entered or was siphoned into the spring vent during spring high tides; during subsequent spring low tides, a mixture of surface water and groundwater discharged from the spring. **Smith** and **Keith Ludwig** (USGS, St. Petersburg), along with **Inia Soto** (USF doctoral candidate), conducted sampling trips in January and February 2009, when the tidal range was moderate (0.5 m). At that time, siphoning was not observed, and the discharging fluid had a constant salinity (3.4). This vent is one of many known offshore springs along the coastal sections of Pinellas, Pasco, Hernando, and Citrus Counties; however, according to a spring survey conducted by the Southwest Florida Water Management District in 2002-03, Crystal Beach Spring is the only spring discharging large volumes of relatively fresh groundwater; the others appear to have stopped flowing. What keeps this spring flowing while so many others in the area have become extinct?

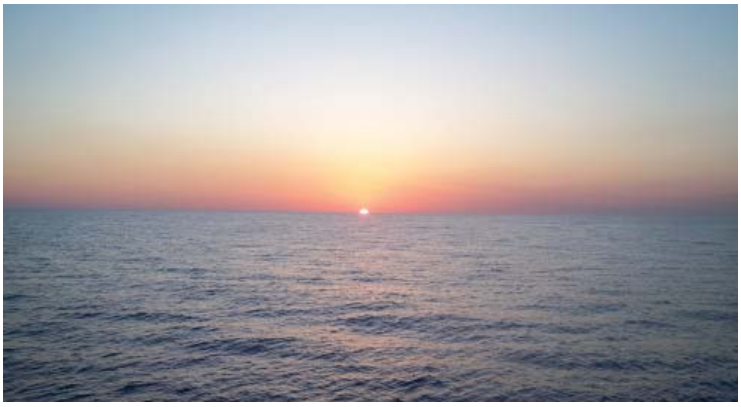
Smith hypothesizes that recharge along the Pinellas Ridge creates a steep hydraulic gradient between the groundwater and adjacent surface-water bodies, subsequently driving nutrients derived from human activities (such as fertilizer application and septic-system seepage) to the coastal ocean. Accompanying the Crystal Beach Spring effluent are relatively elevated levels of dissolved inorganic nitrogen (141.6 mM), primarily in the form of nitrate. Judging from estimated spring-discharge rates and measured nutrient concentrations, the total dissolved inorganic nitrogen being discharged by the spring is estimated at 10^3 to 10^4 mol/d, a similar magnitude as in major rivers feeding Tampa Bay ($10^{4.5}$ mol/d of dissolved inorganic nitrogen). If the spring is fueled by local recharge along the topographic high, then similar nutrient fluxes may be expected along the rest of Pinellas County adjacent to the ridge. So, the next question to address is whether there is evidence of submarine groundwater discharge offshore from the Pinellas Ridge in areas besides St. Joseph Sound.

In late February 2009, **Smith** accompanied **Lisa Robbins** (USGS), **Paul Knorr** (USGS/USF), and **Xuewu Liu** (USF) during a cruise to map surface-water CO_2 concentrations (read about similar research cruises in *Sound Waves*, April 2009, URL **http://soundwaves.usgs.gov/2009/04/fieldwork2.html**). To test for evidence of submarine groundwater discharge along the west Florida shelf, **Smith** measured surface-water ^{222}Rn, a naturally occurring radioactive gas with a short half-life (3.8 days) that is much more concentrated in groundwater than in surface water. Interestingly, surface-water ^{222}Rn activity was 2 to 3 times higher off the Pinellas County peninsula than in coastal waters with similar water depths, suggesting enhanced submarine groundwater discharge off the peninsula. Similar ^{222}Rn enrichments were observed in the waters off Pinellas County during the mid-1980s, indicating a persistent source of ^{222}Rn. **Smith** is conducting additional surveys to refine the spatial extent of the discharge area and to determine how this source may influence nutrient budgets on the west Florida shelf.

^{222}Rn activity was measured with a commercially available radon-in-air system known as the RAD7 (Durridge Co. Inc.). Here, three of these systems are connected to an air-water exchanger (small blue acrylic cylinder on left) that aspirates the water, allowing radon to be transferred from the water to the air. Each RAD7 has an internal pump that transfers the accumulated radon atoms into a chamber where they are counted. When mapping large areas, multiple RAD7s are used simultaneously to increase sampling resolution.

Smith joined the USGS after completing his Ph.D. in Oceanography and Coastal Sciences at Louisiana State University under the direction of **Jaye Cable**. **Smith** received his B.S. and M.S. degrees at East Carolina University, where he worked on a project with the North Carolina Coastal Geology Cooperative that was primarily funded by the USGS Coastal and Marine Geology Program. His M.S. thesis was focused on deciphering the late Holocene stratigraphy of two sections of the Outer Banks of North Carolina, using lithology, benthic-foraminiferal assemblages, ground-penetrating radar, and geochronology.

For more information about **Smith's** study of submarine groundwater discharge along the west Florida Shelf, contact **Christopher G. Smith**, U.S. Geological Survey, 600 Fourth Street S., St. Petersburg, FL 33701, telephone (727) 803-8747 (ext. 3035), fax (727) 803-2032, e-mail **cgsmith@usgs.gov**.



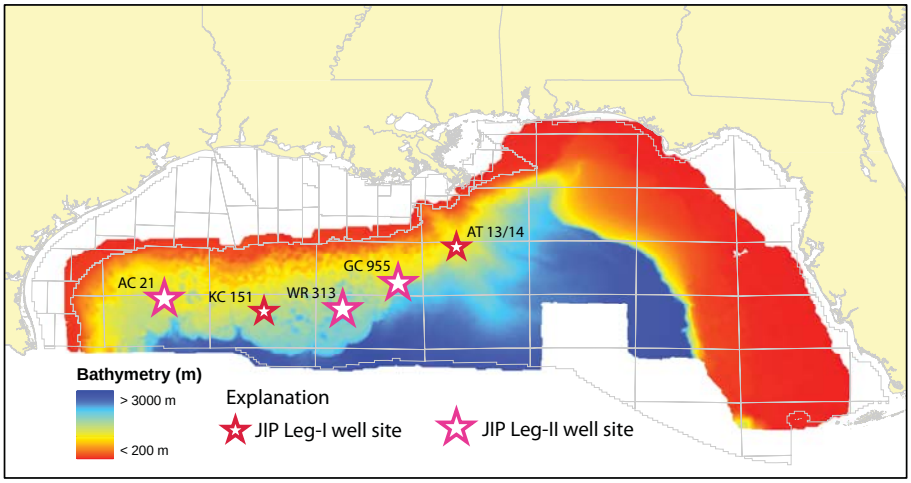
A beautiful sunset on the Gulf of Mexico, one of the best ways to conclude a productive cruise.

Significant Gas Resource Discovered in U.S. Gulf of Mexico

The U.S. Gulf of Mexico contains very thick sections of gas-hydrate-rich reservoir rocks, which have the potential to produce gas with current technology.

Recent drilling by a government and industry consortium confirms that the Gulf of Mexico is the first offshore area in the United States with enough information to identify gas-hydrate energy-resource targets with a potential for gas production.

Gas hydrate, a substance composed of natural gas and water, is thought to exist in great abundance in nature and has the potential to be a significant new energy source to meet future energy needs. Before this expedition, there was little documentation that gas hydrate occurred in resource-quality accumulations in the marine environment.



Sites drilled during Legs I and II of the Gulf of Mexico Gas Hydrate Joint Industry Project (JIP). AC, Alaminos Canyon; AT, Atwater Valley; GC, Green Canyon; KC, Keathley Canyon; WR, Walker Ridge.

"This is an exciting discovery because for the first time in the U.S. Gulf of Mexico, we were able to predict hydrate accumulations before drilling, and we discovered thick, gas-hydrate-saturated sands that actually represent energy targets," said U.S. Geological Survey (USGS) Energy Program Coordinator **Brenda Pierce**.

Drilling vessel Helix Q4000 *at sea in the Gulf of Mexico. Photograph courtesy of Helix Energy Solutions.*

"We have also found gas hydrate in a range of settings, including gas hydrates in sand reservoirs, thick sequences of fracture-filling gas hydrates in shales, and potential partially saturated gas hydrates in younger systems," said USGS scientist **Timothy Collett**. "These sites should provide a wealth of opportunities for further study and data collection that will enable significant advances in our understanding of the nature and formation of gas-hydrate systems."

The U.S. Department of Energy (DOE), the USGS, the U.S. Minerals Management Service (MMS), and a group of U.S. and international energy-industry companies under the management of Chevron were responsible for conducting this first-ever drilling project to collect geologic data on gas-hydrate-bearing sand reservoirs in the Gulf of Mexico. Field operations during the expedition were also supported by AOA Geophysics, the Borehole Research Group at Lamont-Doherty Earth Observatory of Columbia University, Schlumberger, and the crew of the drilling vessel *Helix Q4000*. The most important technical accomplishments include:

- The expedition collected a comprehensive set of logging-while-drilling (LWD) data through expected gas-hydrate-bearing sand reservoirs in seven wells at three sites in the Gulf of Mexico.
- LWD sensors provided unprecedented information on the nature of the sediment and the occurrence of gas hydrate.
- The expedition discovered gas hydrate in both sand- and fracture-dominated reservoirs.
- The discovery of thick gas-hydrate-bearing sands validates the predrilling integrated geological and geophysical approach used to identify the targets, and provides increased confidence in assessing the energy-

(Gulf of Mexico Gas continued on page 5)

(Gulf of Mexico Gas continued from page 4)

resource potential of marine gas hydrates.

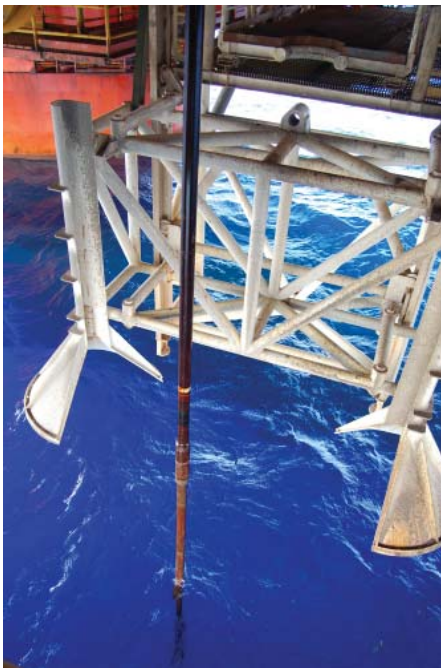
- Gas-hydrate-bearing sand reservoirs 50 to 100 ft thick were discovered at the Walker Ridge and Green Canyon drill sites.
- The discovery of concentrated gas hydrate in sand reservoirs has made Walker Ridge and Green Canyon prime sites for future research drilling, coring, and production testing.

The 21-day expedition, conducted in April and May 2009, was Leg II of the Gulf of Mexico Gas Hydrate Joint Industry Project (JIP). The 2005 JIP Leg I drilling program focused on possible drilling hazards related to gas hydrate in fine sediment. The primary objective of the JIP Leg II expedition was to collect a comprehensive suite of LWD data over gas-hydrate-bearing sand reservoirs and to identify sites for future drilling, logging, and coring programs. The ultimate goal of the current phase of the JIP effort is to gain further insight into the nature, formation, occurrence, and physical properties of gas-hydrate-bearing sediment for the purpose of both resource appraisal and gas-hydrate hazard assessment.

Assembling drill pipe and deploying logging tools from the Helix Q4000.

Additional information about USGS research on natural-gas hydrates is posted on the USGS Energy Resources Web site at URL **http://energy.usgs.gov/**. To learn more about gas-hydrate research in the Gulf of Mexico and the results of the 2009 expedition, visit the DOE National Energy Technology Laboratory's National Methane Hydrates R&D Web site at URL **http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/2009GOMJIP/** or contact **Brenda Pierce**, e-mail, **bpierce@usgs.gov**, telephone (703) 648-6421; or **Tim Collett**, e-mail **tcollett@usgs.gov**, telephone (720) 936-2372.

JIP Leg II used an advanced suite of logging-while-drilling (LWD) tools (examples shown above), which provided unprecedented three-dimensional images of gas-hydrate-bearing sediment. Details about the LWD tools are posted on a DOE Web site about the cruise at URL ***http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/2009GOMJIP/****.*



Drill pipe deployed from the Helix Q4000 *penetrated 1,000s of feet below the sea floor.*

Assessing Offshore Marine Sand Deposits with Probabilistic Models

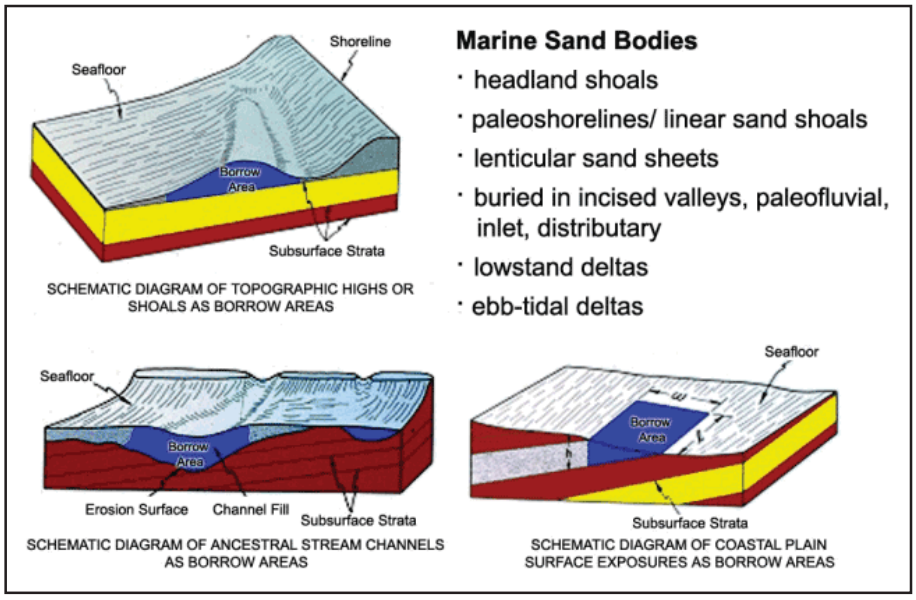
By S. Jeffress Williams, James D. Bliss, and Matthew A. Arsenault

Mapping the distribution of mineral resources of the United States has been a central element of the U.S. Geological Survey (USGS)'s research mission since the agency was established by the Organic Act of 1879, which called for "the classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain."

Although much of the effort over the past 130 years has gone into studying and mapping terrestrial regions, most U.S. territory extends offshore across the continental margins, 200 mi (360 km) to the seaward limits of the Nation's Exclusive Economic Zone (EEZ), designated in 1983. These regions on the continental margin have been little mapped or studied, and basic information—such as geologic maps of the sea floor, understanding of the nature and distribution of sedimentary deposits, and mineral-resource assessments—is sparse.

The submerged continental margins are the product of the underlying geology and dynamic oceanographic processes, particularly processes associated with the late Quaternary marine transgression, during which sea level rose about 120 m over the past 21,000 years since the Last Glacial Maximum. Taken together, these drowned regions of the U.S. EEZ are larger than the continental United States, and they contain submerged landforms that provide various functions and benefits. Some parts of the continental margins also contain unconsolidated mineral deposits, such as sand and gravel, that are potential aggregate resources.

Coastal erosion caused by a combination of natural processes (such as storms, sea-level rise, and land subsidence) and human activities (such as the building of dams and levees that reduce sediment input to coastal systems) is a problem for all coastal States. Population and development in the coastal zone continue to increase, placing more people and infrastructure at risk in vulnerable coastal areas. As predicted climate change accelerates global sea-level rise and increases storminess, coastal regions will undergo even greater erosion and storm-surge flooding in the near future.



Examples of marine sand bodies on U.S. continental shelves. Marine sand bodies have complex geologic histories, occur both buried and exposed at the sea floor, and commonly have been greatly modified by marine processes associated with sea-level rise since the end of the Last Glacial Maximum about 21,000 years ago. Nearshore marine sand bodies of the types shown offer the best potential sources for high-quality sand for beach nourishment. From USGS Bulletin 2209-N.

A practice used to offset the negative impacts of coastal erosion in certain areas is beach nourishment, a method of dredging sand from offshore areas and pumping it ashore to widen and elevate the beach and dune. Beach nourishment is viewed for many developed coasts as a cost-effective and environmentally acceptable short-term (decades of protection) method for mitigating coastal erosion, reducing storm and flooding risk, and restoring degraded coastal ecosystems. For beach nourishment to be successful, however, large volumes of high-quality sand are necessary. For project benefits to exceed costs, the sand deposits must be located reasonably close to the beaches being considered for nourishment.

Sand bodies on the inner continental shelf are commonly deemed desirable sources for beach nourishment because of the quality of the sand and its proximity to the coast. Sand shoals off headlands, sand deposits in drowned stream channels, and sand deposits at the edge of drowned shorelines are a few examples of potential "borrow areas," where sand could be dredged for use in beach nourishment. Demand for offshore sand and gravel is likely to increase over the next 50 years as accelerated sea-level rise and increased storminess caused by climate change increase coastal erosion and flooding hazards. Demand for offshore marine aggregates might also increase as onshore supplies of aggregate are depleted in some parts of the country. Turning to offshore marine aggregates, however, is not a simple solution. The sea-floor areas containing sand bodies commonly also host important benthic habitats that are damaged by dredging; and for many U.S. coastal areas, the offshore sand resources appear to be inadequate to meet longer-term needs for beach nourishment and coastal protection.

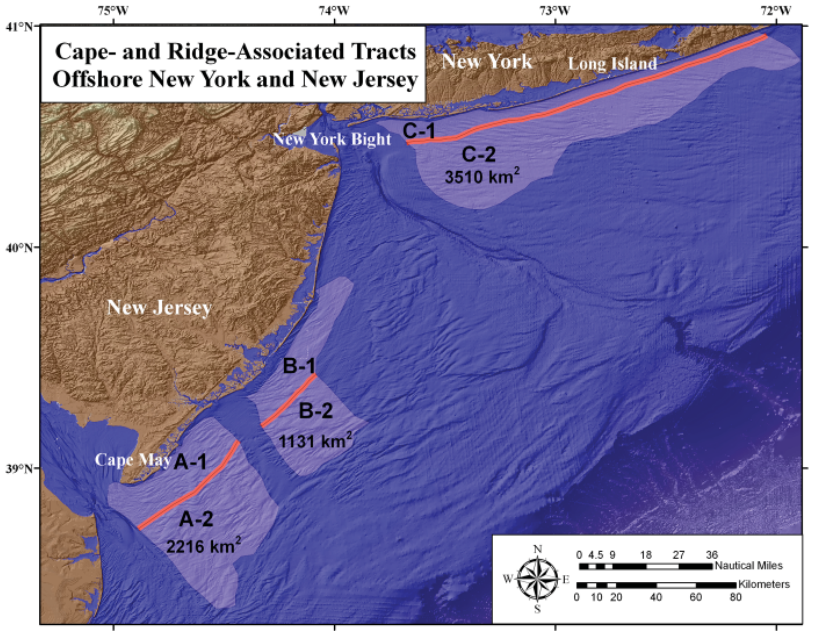
To help meet societal needs, the USGS Marine Aggregates Resources and Processes (MARP) Project (see URL **http://woodshole.er.usgs.gov/project-pages/aggregates/**) focuses on characterizing and mapping offshore sediment and developing statistical models and techniques for assessing marine sand-and-gravel

(Offshore Sand continued on page 7)

(Offshore Sand continued from page 6)

resources. One project task involves gathering a wide variety of marine geologic data into the usSEABED system (see URL **http://walrus.wr.usgs.gov/usseabed/**). This system provides a centralized, fully integrated digital database of marine geologic data collected over the past 50 years by the USGS, other Federal and State agencies, universities, and private companies. To date, approximately 400,000 data points from the U.S. EEZ reside in the usSEABED system, which combines a broad array of physical data and information (both analytical and descriptive) about the sea floor, including sediment textural, statistical, geochemical, geophysical, and compositional information. Data from usSEABED are available to the marine community through USGS Data Series publications. Already published are USGS Data Series reports for three regions: offshore the Atlantic coast (DS 118, URL **http://pubs.usgs.gov/ds/2005/118/**, the Gulf of Mexico and Caribbean (DS 146, URL **http://pubs.usgs.gov/ds/2006/146/**), and the Pacific coast region (DS 182, URL **http://pubs.usgs.gov/ds/2006/182/**). Updates of Data Series DS 118 and DS 146 with additional data sets are expected in summer 2009; similar Data Series reports for Hawai‘i and Alaska are in preparation.

Another project task deals with modeling and assessing offshore deposits. Two reports describing the development of a probabilistic model and its application to the New York-New Jersey continental-shelf region were published in USGS Bulletin 2209 this year. The model presented in chapter M (Bliss, J.D., Williams, S.J., and Bohm, K.S., 2009) is believed to be the first such statistical model developed for marine sand bodies by using a three-part mineral-resource-assessment approach to an offshore region. In chapter N (Bliss, J.D., Williams, S.J., and Arsenault, M.A., 2009), the authors conclude that an estimated 3.9 billion m^3 of marine sand resources is present in marine sand deposits associated with capes and sand ridges in three representative regions, or tracts, on the continental shelf off New York and New Jersey. Admittedly, only part of these probable resources are actually available for production, depending largely on environmental, economic, preemptive-use, and political factors. These estimates, derived from probabilistic distributions of sand resources, were made by using the deposit models and Monte Carlo simulation techniques described in Chapter M.



Three tracts (A-2, B-2, C-2) assessed for cape- and ridge-associated marine sand deposits in the New York and New Jersey region. Nearshore tracts (A-1, B-1, C-1), separated from offshore tracts by red lines, were described in earlier publications. From USGS Bulletin 2209-N.

The estimated sand-resource volumes discussed in chapter N are for only three tracts and just for the Holocene sand resources contained in cape- and ridge-associated marine sand deposits. Other areas may qualify as tracts for this deposit type on the Atlantic continental shelf off New Jersey and New York but are not delineated or addressed in this initial evaluation. Marine sand also occurs in other deposit types of different geologic ages (for example, paleostream channels, blanket and outwash deposits, ebb-tidal shoals, and paleoshorelines and deltas formed at times of lower sea level), which are present on the Atlantic continental shelf off New Jersey and New York but were not considered in this assessment. Results of this modeling and assessment of marine sand resources are expected to be used by Federal and State resource and regulatory agencies in carrying out their missions.

The MARP plan is to apply the Monte Carlo simulation technique and the three-part assessment approach to other areas on the Atlantic coast margin, and to produce a suite of online maps based on usSEABED showing sea-floor-sediment characteristics and distribution. The initial maps for the Atlantic continental shelf and the northern Gulf of Mexico will be published in late 2009.

Full references for the two recent reports on modeling and assessing offshore deposits are:

Bliss, J.D., Williams, S.J., and Bohm, K.S., 2009, Modeling cape- and ridge-associated marine sand deposits; a focus on the U.S. Atlantic continental shelf, chap. M *of* Bliss, J.D., Moyle, P.R., and Long, K.R., eds., Contributions to industrial-mineral research: U.S. Geological Survey Bulletin 2209-M, 28 p. [URL **http://pubs.usgs.gov/bul/b2209-m/**].

Bliss, J.D., Williams, S.J., and Arsenault, M.A., 2009, Mineral resource assessment of marine sand resources in cape- and ridge-associated deposits in three tracts, New York and New Jersey, United States Atlantic continental shelf, chap. N *of* Bliss, J.D., Moyle, P.R., and Long, K.R., eds., Contributions to industrial-minerals research: U.S. Geological Survey Bulletin 2209-N, 6 p. [URL **http://pubs.usgs.gov/bul/b2209-n/**].

Celebrating the 10th Anniversary of Sound Waves, 1999 to 2009

By S. Jeffress Williams

Ten years have passed since the U.S. Geological Survey (USGS) Coastal and Marine Geology Program formally launched the monthly newsletter *Sound Waves* (URL **http://soundwaves.usgs.gov/**). *Sound Waves* began by covering research-project news from USGS field centers in Woods Hole, Massachusetts; St. Petersburg, Florida; and Santa Cruz and Menlo Park, California. The inaugural edition was published in January 1999. Later, coverage was expanded to include interdisciplinary news and information on all coastal topics and disciplines across the USGS from several coastal-science centers (currently numbering eight), as reflected in the subtitle: "Coastal Science & Research News from Across the USGS." The newsletter has grown from just 8 pages to an average of 15 to 25 pages each month, and responsibility for the professional-style editing, layout, and Web design has been shared in superior fashion by capable and conscientious staff among the three Coastal and Marine Geology Program centers. **Helen Gibbons** (Menlo Park) and **Barbara Lidz** (St. Petersburg) were editors early on and have continued to the present. Here is a list of others who have been instrumental in the success of *Sound Waves* over the years (with duty stations at time of service): **Gabrielle Bodin** (National Wetlands Research Center, Lafayette, Louisiana), **Sara Boore** (Menlo Park), **Jane Ciener** (Menlo Park), **Sandy Coffman** (St. Petersburg), **Becky Deusser** (Woods Hole), **Gaye Farris** (National Wetlands Research Center), **Trent Faust** (St. Petersburg), **Anne Gartner** (Menlo Park), **Joy Geiselman** (Alaska Science Center, Anchorage), **Jan Goodell** (Woods Hole), **Ardis Greatorex** (Woods Hole), **Hannah Hamilton** (Gainesville, Florida), **George Havach** (Menlo Park), **Susan Horton** (National Wetlands Research Center), **Gloria Maender** (Western Ecological Research Center, Tucson, Arizona), **Susan Mayfield** (Menlo Park), **Ellen Mecray** (Woods Hole), **Greg Miller** (Woods Hole), **Sandra Morrison** (Great Lakes Science Center, Ann Arbor, Michigan), **Donna Newman** (Woods Hole), **Cynthia Pimental** (Woods Hole), **Joanne Sedlock** (Woods Hole), **Jolene Shirley** (St. Petersburg), **Laura Torresan** (Santa Cruz), **Rob Wertz** (St. Petersburg), and **Mary Ellen Williams** (Woods Hole).

Sampling of Sound Waves *issues, from early (left) to recent.*

At first, *Sound Waves* was duplicated on paper and mailed to several hundred addresses, but it soon became Web based as it grew in size and the Web became the medium of choice. Over the past decade of putting forth more than 200 cover stories and news articles on the countless accomplishments, awards, and publications of USGS coastal and marine scientists to the broader marine science community, there is much to celebrate—and with pride. For 2009 so far, the newsletter's Web site averages 1,978 visits per day, and the average length of a site visit is 7:59 minutes. The number of monthly e-mail-update subscribers is 1,398.

As Program Coordinator for the Coastal and Marine Geology Program from 1996 to 2000, I realized the need to communicate results of the various projects and activities at the program's three field centers in a timely manner, not only internally but also to other parts of the USGS and to a larger audience outside the USGS. Up until that time, the centers had circulated informal individual newsletters, and the program had produced a Web site and occasional newsletters, but we lacked a consistent and easily accessible instrument to highlight and communicate coastal and marine science results and events across the country. Over the past decade, current Coastal and Marine Geology Program Coordinator **John Haines** and chief scientists at the contributing science centers have continued to support the newsletter.

Meeting the need to communicate research results and news was the objective when the newsletter was created. The success of *Sound Waves* is borne out by continued high-quality content and positive feedback and comments from its numerous readers, those internal to the USGS and those of the external science community, teachers, students, congressional staffers, and the public. These needs are more important than ever, and I have great expectations that *Sound Waves* will continue to meet them well, and well into the 21st century.❁

USGS: Your Resource During Hurricane Season

Science that weathers the storm...

By Jennifer LaVista

When hurricanes strike, you can find critical information to help protect lives and property at the U.S. Geological Survey (USGS) hurricane Web site, URL **http://www.usgs.gov/hazards/hurricanes/2009/**.

More than half of the U.S. population lives within 50 mi of a coast—and coastal populations are increasing. Many U.S. coastal areas, especially the Atlantic and Gulf coasts, will be in the direct path of hurricanes.

"Throughout hurricane season, reliable scientific information is essential in order for emergency managers to keep the American public safe," said Secretary of the Interior **Ken Salazar**. "The USGS provides this science, which helps prevent hazards from becoming disasters."

The USGS hurricane Web site highlights important storm information, such as flood levels near your home; pictures of the coastline before and after the storm; information on the timing, extent, and magnitude of storm tide; and much more.

USGS research and analysis supports the National Oceanic and Atmospheric Administration (NOAA), which is responsible for monitoring and issuing warnings for hurricanes and tropical storms in the United States and its territories. Science to forecast hurricane impacts is a collaborative effort among the USGS, NOAA, the National Aeronautics and Space Administration (NASA), the U.S. Army Corps of Engineers, and others.

Hurricane Ike was still a Category 4 storm on the morning of September 4, 2008, when this photograph was taken from the International Space Station's vantage point of 220 mi above the Earth. The season's ninth named storm was churning west-northwestward through the mid-Atlantic Ocean, sporting winds of 120 nautical miles per hour with gusts to 145. Image from URL ***http://spaceflight.nasa.gov/gallery/images/station/crew-17/html/iss017e015170.html****.*

The USGS strives to reduce the vulnerability of the people and areas most at risk from natural hazards. By working with people from all sectors of society, the USGS and its partners are taking action to prepare for this year's hurricane season. The USGS anticipates that these actions will provide many benefits, including improved monitoring of ground conditions affected by flooding and storm surge, enhanced ability to navigate in a disaster zone, more effective search and rescue operations, and better assessments of the effects on coastlines and ecology.

Students Learn the Practice of Science, and Scientists Further Their Research—Internship Programs at the USGS Center in St. Petersburg, Florida

By Dennis Krohn, Chris Reich, and Ann Tihansky

Various internship programs at the U.S. Geological Survey (USGS) Florida Integrated Science Center (FISC) office in St. Petersburg offer benefits to all. When the USGS chose St. Petersburg 20 years ago as the site for its new marine-science field center, proximity to local marine-science colleges and universities was a key criterion. Since establishment of the center in 1989, student internship programs have played a critical role in the USGS research agenda. Many interns have gone on to research careers of their own and often speak warmly of their days at the bottom of the USGS totem pole.

Recently, a new type of internship was begun, inspired by completion of the third USGS building on the University of South Florida (USF) St. Petersburg campus. Both USGS and USF staff occupy the shared facility. The new internship program has a different model from that of the long-established internships. Initiation of this new program is a good time to review the various internship opportunities available at the St. Petersburg center.

USGS-USF St. Petersburg Internship Program The new internship program is conducted in cooperation with the Department of Environmental Science, Policy, and Geography (ESP&G) at USF St. Petersburg. The program is unusual in sev-

(Internships continued on page 10)

(Internships continued from page 9)

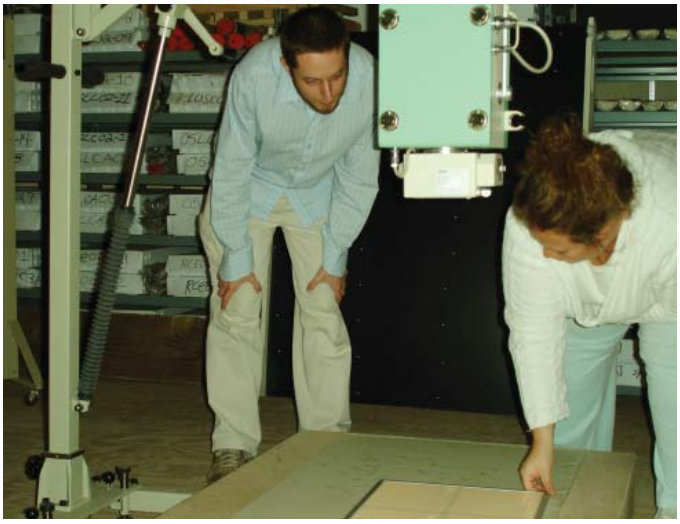
eral ways. It is available during the academic year, and students must complete an academic report at the end of each term outlining what they accomplished during their time in the program. This effort requires planning by both the student and the mentoring scientist. The USF coordinator approves the student reports, and the students, upon completion of all requirements, receive academic credit for their participation. Furthermore, because the USF Environmental Science, Policy, and Geography Department includes a policy component, it allows students to intern in areas outside the traditional field- and laboratory-based sciences.

The new program began during the past academic year with two interns: **Joe Boyle**, working with USGS sponsor **Lisa Robbins**; and **Adis Muslic**, working with USGS sponsor **Kristine DeLong**. Initial feedback has been extremely positive. **Robbins** said, "It has just been fantastic. **Joe** is a hard worker and has immersed himself in the data. We are all learning a lot. The promising start to the program seems to be a good foundation for a sustained cooperative effort."

USGS contact: **Dennis Krohn**, **dkrohn@usgs.gov**

USF contact: **Donny Smoak**, **smoak@stpt.usf.edu**

***Joe Boyle**, an intern in the new USGS-USF St. Petersburg program, performs data analysis for **Lisa Robbins** as part of her project on the Response of Florida Shelf Ecosystems to Climate Change.*



***Adis Muslic** (left), an intern in the new USGS-USF St. Petersburg program, helps **Kristine DeLong** with X-ray analysis of Gulf of Mexico coral cores to look for possible evidence of ocean acidification in annual-growth density bands. This work is part of the Florida Integrated Science Center (FISC) Coral Reefs project.*

USGS/USF Cooperative Assistantships The USGS/USF Cooperative Assistantship program has been one of the USGS St. Petersburg center's staple ways of providing support for promising undergraduate students. The awards are designed to foster cooperative research between the USGS and the USF College of Marine Science. Generally, a maximum of four students can be supported under this program in any given year. The students choose either a 2-year M.S. program or a 3-year Ph.D. program. The assistantship is a mutually beneficial arrangement. Many of the participating students are given office space at the USGS facilities. The assistantship program allows the USF College of Marine Science to attract and retain some of the brightest students in the United States. The program is of sufficient breadth that it supports students working in both the USGS St. Petersburg center and the USGS Tampa office for hydrological research.

USGS contact: **Dr. Jack Kindinger**, **jkindinger@usgs.gov**

USF contact: **Dr. Van Vleet**, **vanvleet@marine.usf.edu**

USGS-Eckerd College Internship Program For more than 15 years, the USGS has held a cooperative agreement with Eckerd College to provide mentorship and work experience for undergraduate students through the USGS-Eckerd College internship program, and to stimulate joint research projects in the fields of marine science, biology, and remote sensing. Involvement between USGS scientists and student interns enhances the educational and intellectual experience for the students. Interest in this internship has blossomed during the past 5 years. The number of students applying 5 years ago was just enough to fill the six intern positions; in contrast, approximately 20 to 30 applicants are anticipated for fiscal year 2010 (October 1, 2009, to September 30, 2010), including students from the departments of biology, chemistry, and computer science, as well as marine science. The USGS-Eckerd College internship program has grown and gained strength, much to the pleasure and benefit of the scientists who become mentors to the incoming students.

USGS contact: **Chris Reich**, **creich@usgs.gov**

Eckerd College contact: **Greg Brooks**, **brooksgr@eckerd.edu**

USGS-USF St. Petersburg Journalism Internship Program Scientific journalism plays an important role in conveying the latest discoveries in science and technology to the general public. The USGS-USF St. Petersburg journalism internship program is designed to prepare a journalist for writing about scientific and environmental topics and issues. Through the internship, journalism students get practical hands-on experience in interviewing scientists, working on deadline, and dealing with production, as well as writing pieces that range from press releases to indepth feature articles, all focused on the latest scientific topics. The internship puts jour-

(Internships continued on page 11)

(Internships continued from page 10)

nalists in a scientific environment, where they gain experience and knowledge by working directly with scientists. The interaction helps both the journalists and the scientists, exposing journalists to the rigorous scientific review process, while helping scientists put their technical subjects into a more relevant context for greater understanding by the general public. In addition, access to USGS scientists provides journalists an opportunity to build relationships with expert contacts that can last beyond the internship. The journalism intern program is tailored to students' goals and relies on their motivation and interest. Examples of stories by and about previous interns are posted on the following Web pages:

- **http://baysoundings.com/fall08/**
- **http://soundwaves.usgs.gov/2008/10/research.html**
- **http://soundwaves.usgs.gov/2008/09/staff.html**
- **http://soundwaves.usgs.gov/2008/09/outreach.html**
- **http://soundwaves.usgs.gov/2008/08/outreach.html**
- **http://soundwaves.usgs.gov/2008/01/fieldwork3.html**
- **http://soundwaves.usgs.gov/2007/01/**
- **http://soundwaves.usgs.gov/2005/09/outreach3.html**
- **http://soundwaves.usgs.gov/2005/07/outreach5.html**

USGS contact: **Ann Tihansky**, **tihansky@usgs.gov**

***Allison Rohman**, an intern from Eckerd College, works on sediment-sample analysis for **Jen Flannery** as part of the Gulf of Mexico Climate and Environmental History project. Single-celled protists known as foraminifera will be picked out of the samples and used to reconstruct the climate of the Gulf of Mexico over the past several thousand years.*

USF contacts: **Tony Silvia**, **tonys@stpt.usf.edu** or **Bob Dardenne**, **dardenne@stpt.usf.edu**

NAGT-USGS Cooperative Summer Field Training Program The National Association of Geology Teachers (NAGT) and the USGS cooperate in an internship program for Earth-science students nominated by their field-camp directors. Begun in 1965, the NAGT-USGS Cooperative Summer Field Training Program is the longest continuously running internship in the Earth sciences. Over the past 40 years, more than 1,600 students have participated, with an impressive number of these individuals becoming full-time employees of the USGS. The names and affiliations of the 28 interns who participated in the 2008 program throughout the USGS can be viewed at URL **http://serc.carleton.edu/nagt/programs/08interns.html**.

USGS St. Petersburg contact: **Pat Mullan**, **pmullan@usgs.gov**

USGS national contact: **Bob Ridky**, **rridky@usgs.gov**

These programs have made valuable contributions to the core USGS research mission. Not only do they provide much-needed help to overextended scientists, but they also provide an opportunity for scientists to interact with young people and find potential candidates to continue in the discipline. The USGS St. Petersburg staff has benefited enormously from this group of potential scientists. With the addition of the new USGS-USF St. Petersburg internship program, we hope to continue to strengthen that tradition in the future. ❁

Hot Ticket—USGS Open House in Menlo Park, California

By Helen Gibbons

Thousands of visitors braved unseasonably hot weather to attend the 9th triennial Open House at the U.S. Geological Survey (USGS) center in Menlo Park, California. The 3-day event began with a preview day on Friday, May 15, for invited VIPs and school groups from around the San Francisco Bay area. More than 1,000 students swarmed over the campus with their teachers and chaperones, eagerly exploring dozens of exhibits set up indoors and out. The campus was open to the general public on Saturday and Sunday (May 16 and 17), when visitors of all ages enjoyed a broad array of offerings, such as live talks in the Presentation Theater, hands-on activities, and the universal favorite: talking with scientists about what they do.

(Open House continued on page 12)

*Coastal and Marine Geology Team member **Quenton Smith** kicked off the Open House with a beautiful performance of "The Star-Spangled Banner" (URL **http://openhouse.wr.usgs.gov/2009-opening.html**). Photograph by **Mike Diggles**, USGS.*

(Open House continued from page 11)

Here are some of the displays related to coastal and marine science:

Dress Like a Marine Geologist In this popular activity, organized by **Clint Steele** and **Carolyn Degnan**, visitors put on field attire and, through a little computer magic, were photographed in the field setting of their choice. (See the results at URL **http://walrus.wr.usgs.gov/infobank/programs/html/openhouse/2009.html**.)

Fly Over the Sea Floor It looked as if the water had been drained away to expose the bed of Lake Tahoe and the sea floor off Los Angeles and San Diego when **Pete Dartnell** treated visitors to virtual flights over underwater terrain revealed by USGS bathymetric data. (See examples at URL **http://walrus.wr.usgs.gov/pacmaps/**.)

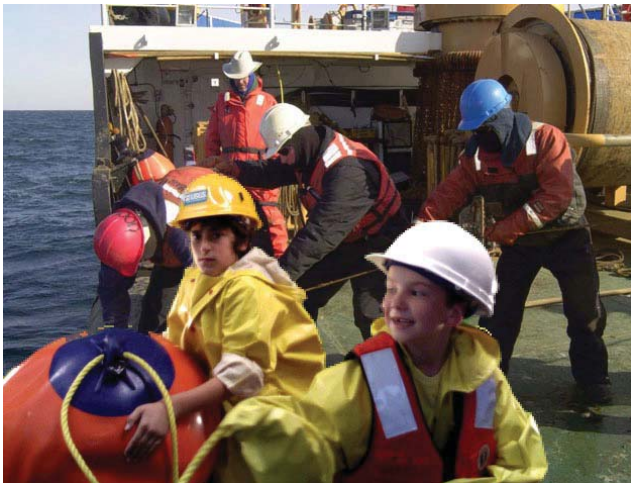
Mapping California Coast State Waters Some of the Coastal and Marine Geology Team's most recent work was highlighted in maps of the sea floor off Half Moon Bay, California, showing bathymetry, roughness, sediment distribution, habitat type, and more. **Brian Edwards** organized this display, which also featured sea-floor images used to "ground-truth" the mapping data, and the large camera sled used to collect them.

Under San Francisco Bay Visitors inspected sediment samples and viewed colorful posters and a computer flythrough of topography beneath the waves of San Francisco Bay and the Golden Gate. **John Chin** and **Don Woodrow** organized this display, which offered numerous handouts, including postcards of sea-floor bathymetry and copies of *Shifting Shoals and Shattered Rocks–How Man Has Transformed the Floor of West-Central San Francisco Bay* (USGS Circular, 1259, URL **http://pubs.usgs.gov/circ/2004/c1259/**).

*Left, Volunteer for Science **James Jones** (far left) looks on while USGS scientist **Clint Steele** (seated) sets up a background image from USGS studies in the Grand Canyon for visitors at "Dress Like a Marine Geologist" (photograph by **Bill Adams**, USGS). Above, the result.*

Topo Salad Trays In an activity led by **Florence Wong**, visitors stacked up clear-plastic trays with a contour line on each to produce three-dimensional models of Monterey Canyon on the central California coast and Angel Island in San Francisco Bay. (See instructions at URL **http://online.wr.usgs.gov/outreach/topo_instructions.html**.)

Microfossils, Volcanic Ash, and Tree Rings—Oh My! At this multifaceted display—presented by **Elmira Wan**, **Mary McGann**, **Scott Starratt**, **David Wahl**, **John Barron**, **Holly Olson**, and **Margaret Keller—**visitors used microscopes and magnifiers to view items that help scientists better understand climate change; the timing, magnitude, and environmental impact of volcanic eruptions and other geologic events; and the origin of fine-grained petroleum-source rocks.



Visitors get into the action at "Dress Like a Marine Geologist."

Mid-Ocean Ridges **Carol Reiss** hosted this display, at which visitors imagined what it's like to descend into the deep sea in a submersible, viewed video footage of deep-sea hot springs at a mid-ocean spreading ridge, and inspected samples of minerals precipitated from the hot water and animals that live around the springs.

Imaging the Ocean Floor With assistance from **Mike Boyle**, **Carol Reiss** also displayed a sidescan-sonar "fish" used to image the sea floor, plus a computer monitor playing back data collected from various offshore areas.

Science Resources for Teachers Teachers mobbed this unstaffed display (put together by **Carol Reiss**), which offered free handouts on plate tectonics and other topics based on Science Content Standards for California Public Schools (for grades K-12).

A Visual Tour of Tsunamis featured **Eric Geist** in the Presentation Theater, demonstrating computer models that show how tsunami waves move away from the area where they were triggered and collide with coastlines both near and far from the source area. (See example at URL **http://walrus.wr.usgs.gov/tsunami/sumatraEQ/SumatraNW2.html**.)

How Clean Is Clean? **Brent Topping** and **James Kuwabara** helped visitors use a salinity meter to guess which water was which (ocean, bay, tap water, bottled water, high-purity lab water).

Adventures in Geochemistry **Bob Rosenbauer**, **Burt Thomas**, **Nancy Prouty**, and others invited visitors to smell samples of oil from different sources

(Open House continued on page 13)

(Open House continued from page 12)

and explained how the chemistry of an oil sample not only gives it a distinctive smell but also serves as a "fingerprint" that can be used to determine its source—such as a natural seep or an oil spill.

LIDAR (LIght Detection And Ranging) In an activity organized by **Diane Minasian**, visitors were scanned with a terrestrial lidar instrument, which uses laser light reflected from surfaces to create high-resolution, three-dimensional images. Lidar data are particularly useful for documenting landscape change, such as hurricane damage and coastal-cliff erosion. (See URL **http://pubs.usgs.gov/fs/2006/3111/**.)

Using Current Drifters to Track Coral Larvae in Hawai'i **Susie Cochran**, **Amy Draut**, **Josh Logan**, **Ann Gibbs**, **Gerry Hatcher**, **Nancy Prouty**, and **Tom Reiss** put together this exhibit, at which visitors viewed current drifters and their components, learned how drifters were used to track dispersal of coral larvae in Hawaiian waters, and heard about additional USGS studies of Hawai'i's coral-reef ecosystems. (See URLs **http://soundwaves.usgs.gov/2003/08/**, **http://coralreefs.wr.usgs.gov/**, and **http://pubs.usgs.gov/sir/2007/5101/**.)

Instrumented Personal Watercraft for Mapping the Sea Floor **Andrew Stevens** and **Guy Gelfenbaum** invited visitors to climb aboard personal watercraft equipped with echosounders and Global Positioning System (GPS) units. Visitors learned how USGS scientists use such watercraft to map the sea floor near the shore, and viewed photographs of surveying activities and some of the resulting maps. (See URL **http://walrus.wr.usgs.gov/coastal_processes/sfbight/methods.html#nearshore**.)

*Wildlife biologist **Christine Alfano** (right) of the USGS Western Ecological Research Center's Santa Cruz Field Station manipulates the cast of a juvenile killer whale skull to show Open House visitors how the jaws work. Photograph by **Helen Gibbons**.*

***Nancy Prouty** explains to young visitors how corals grow and how scientists count their annual density bands by using X-rays, like the X-rays doctors use to view people's bones. Scientists use coral-skeleton banding to determine coral ages and to better understand past climatic and environmental changes. Photograph by **Amy Draut**.*

Sea Otter Research This large exhibit was organized by **Nicole LaRoche**, **Tim Tinker**, **Christine Alfano**, and others from a cooperative-research unit comprising the USGS Western Ecological Research Center's Santa Cruz Field Office and the Tinker/Estes Lab at the University of California, Santa Cruz. Visitors stroked sea-otter pelts, touched casts of marine-mammal skulls, learned how microscopic growth layers in cross sections of sea otter teeth are used to determine sea otters' ages, and handled research tools, such as a spotting scope, radio transmitter, and receiver/antenna. (See URL **http://brd1.ucsc.edu/**.)

Submarine Landslides Can Cause Destructive Tsunamis Led by **Holly Ryan** and **Homa Lee**, exhibitors invited visitors to slide objects down a ramp into a tub of water to see what type of landslide triggers "tsunamis." Participants then watched the waves topple structures they had placed on a "coastline" at the far end of the tub.

(Open House continued on page 14)

(Open House continued from page 13)

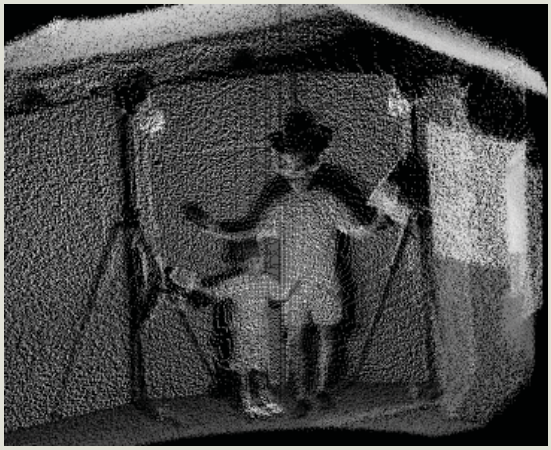
Many of them enjoyed standing where they could be splashed by the cooling water.

Sequoia—Bald Eagle from the San Francisco Zoo A live bald eagle, whose damaged tail prevents her from living in the wild, was the star of a display about ecosystem recovery from the impacts of DDT-contaminated sediment off southern California. (See URL **http://chil.vcoe.org/eagle_cam.htm**.) **Kathy Hobson** of the San Francisco Zoo and **Greg Baker** of the National Oceanic and Atmospheric Administration kindly organized this exhibit.

Jon Boat—Flat-Bottomed Boat Used for Shallow-Water Mapping This unstaffed display was a hit with children, who enjoyed climbing into the boat and putting on life vests.

Live Music Several musical groups whose members include USGS employees performed for visitors. Particular highlights were two songs composed by the 19th-century geologist and mineralogist **J.D. Dana** (whose book on mineralogy is still used as a college text) while he was part of the U.S. Exploring Expedition of 1838-42 in Antarctica. "The Old Peacock" (named for one of the ships) and "Antarctic Mariner's Song" were performed with the permission of a book collector who recently bought the expedition's unpublished songbook.

A complete list of exhibits, plus photographs of the event and video footage of the opening ceremony, is posted on the Open House Web site at URL **http://openhouse.wr.usgs.gov/**.



*Upper left, **Diane Minasian** (foreground) scans a visitor with a tripod-mounted lidar (light detection and ranging) instrument. Upper right, the result. Left, more visitors. The scans were taken at low resolution so they could be processed quickly for viewing.*

*San Francisco Zoo volunteer **John Flynn** answers visitors' questions about bald eagle **Sequoia**. Photograph by **Helen Gibbons**.*

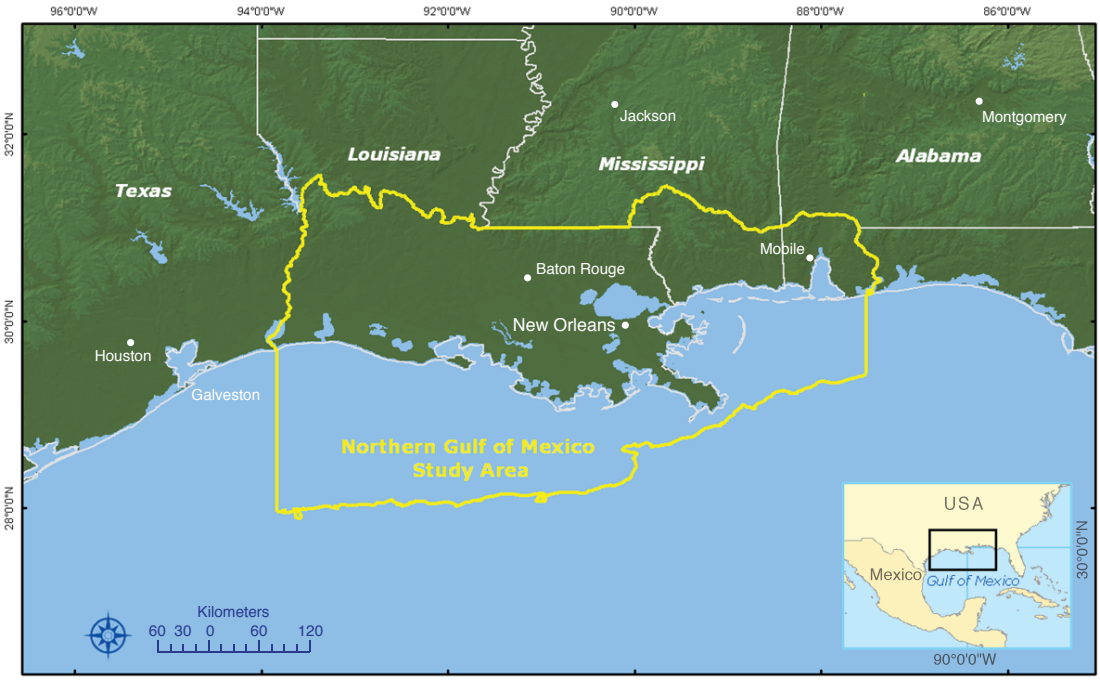
Some behind-the-scenes players from the Coastal and Marine Geology team helped make the Open House run smoothly: **Dave Hogg** and **Mike Boyle** of the Marine Facility provided electrical wiring to exhibits in and near the Volcanoes, Coasts, and Oceans tent; and **Carol Reiss** and **Helen Gibbons** served on the Open House Steering Committee. **Quenton Smith** was front and center when she opened the event with the national anthem at Friday's Opening Ceremony, backed up by fellow band members from the Vintage Music Collective (URL **http://openhouse.wr.usgs.gov/2009-opening.html**). Many additional team members, their names too numerous to list here, helped set up, staff, and tear down Open House displays.

Everyone involved can take pride in the public's enthusiastic response to the Open House. Numerous visitors e-mailed their thanks, such as: "I especially enjoyed having access to the staff and getting to ask any questions we wanted," "What we loved was how friendly all of the scientists were at each poster," and "It was great fun for the whole family!"

Annual Science Meeting of the Northern Gulf of Mexico Ecosystem Change and Hazard Susceptibility Project

By Emily Klipp

The Annual Science Meeting of the U.S. Geological Survey (USGS) Northern Gulf of Mexico (NGOM) Ecosystem Change and Hazard Susceptibility Project—also known as the NGOM Project—was held March 24-26, 2009, at the Lindy Boggs International Conference Center on the University of New Orleans' Lakefront Campus. The overall goal of this project is to understand the evolution of coastal ecosystems, the impact of human activities on these ecosystems, and the vulnerability of ecosystems and human communities to intense hurricanes in the coastal areas of Louisiana, Mississippi, and Alabama.



The NGOM Project study area on the northern Gulf Coast includes the coastal margins of Louisiana, Mississippi, and Alabama.

This meeting, led by **John Brock** and **Dawn Lavoie** (USGS), provided a unique opportunity for task and subtask leaders, cooperative partners, and members of the project's Science Advisory and Region Advisory committees to get together and discuss the project. Specific goals were to share updates on scientific progress and products, to plan and coordinate summer 2009 field activities, to identify what is or is not working well and plan any needed course corrections, and to review strategies for developing new partnerships.

*Left to right, **Ioannis Georgiou**, **Mark Kulp**, and **Mike Miner** of the University of New Orleans lead a field trip around the New Orleans area.*

During the afternoon of the second day, University of New Orleans collaborators **Mark Kulp**, **Mike Miner**, and **Ioannis Georgiou** provided a tour of areas relevant to the project around New Orleans, Louisiana. The field trip focused on the geologic framework of eastern New Orleans, the Mississippi River Gulf Outlet (MRGO), the Inner Harbor Navigation Canal (IHNC), and the Gulf Intracoastal Waterway (GIWW). This area of New Orleans and southern Louisiana has been a focus of concern ever since the devastating impact of the 2005 hurricanes. For this reason, a massive flood-protection barrier is being constructed by the U.S. Army Corps of Engineers, with the intention of closing gaps between two separate levee systems. Field-trip participants gained an increased awareness of how the geomorphology and near-surface geology of the area affect flooding hazards and mitigation efforts.

The NGOM Project, which began in October 2006, has made substantial progress in its first few years and has already generated many products: 25 USGS publications, including 4 Circulars, 11 Data Series, 7 Open-File Reports, 1 Fact Sheet, 1 Scientific Investigations Map (9 more are currently in progress), and the NGOM Web site (URL **http://ngom.usgs.gov/**); 11 journal articles, conference papers, and book chapters; and 38 abstracts. Later this year, a special issue of the journal *GeoMarine Letters* will include 12 papers from the NGOM Project.

Owing to its integrated approach, the NGOM Project has provided researchers with a way to investigate, in parallel, Holocene geologic and climatic evolution, historical ecosystem change, present and future (projected) ecosystem structure, and associated hazards to human populations along the northern gulf coast.

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